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(54) **ACTIVE BUCK POWER FACTOR CORRECTION DEVICE**

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G05F 5/00 (2006.01)
H02M 1/42 (2007.01)
H02M 3/158 (2006.01)

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CPC ***H02M 1/4225*** (2013.01); ***H02M 3/1582*** (2013.01); *Y02B 70/126* (2013.01)

(58) **Field of Classification Search**
USPC 323/222, 205, 232, 259, 207, 225, 271, 323/282, 284, 285; 363/90, 95, 97
See application file for complete search history.

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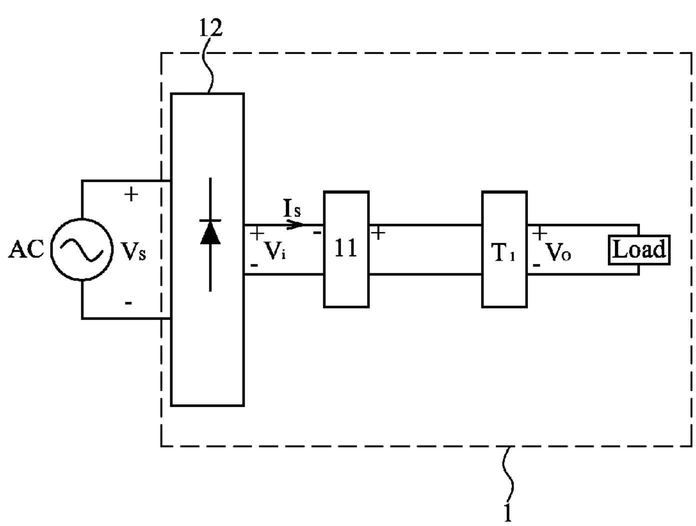
(57) **ABSTRACT**

The present disclose relates to a power active buck power factor correction device, comprising: a AC source; a rectifying device coupled to the AC source for receiving and rectifying the AC source so as to generate an input voltage; a first converting device coupled to the assistance device for receiving, transmitting, converting and storing energy; a load coupled to the first converting device; and an assistance device coupled to the first converting device for generating an assistance voltage. Specifically, the polarity of the assistance voltage is same with the input voltage, but is contrary to an output voltage, so that the first converting device may continue to work and receive an input current under the input voltage is smaller than the output voltage while the discontinue time of the input current is getting shorter so as to obtain the perfected power factor correction effect.

14 Claims, 16 Drawing Sheets



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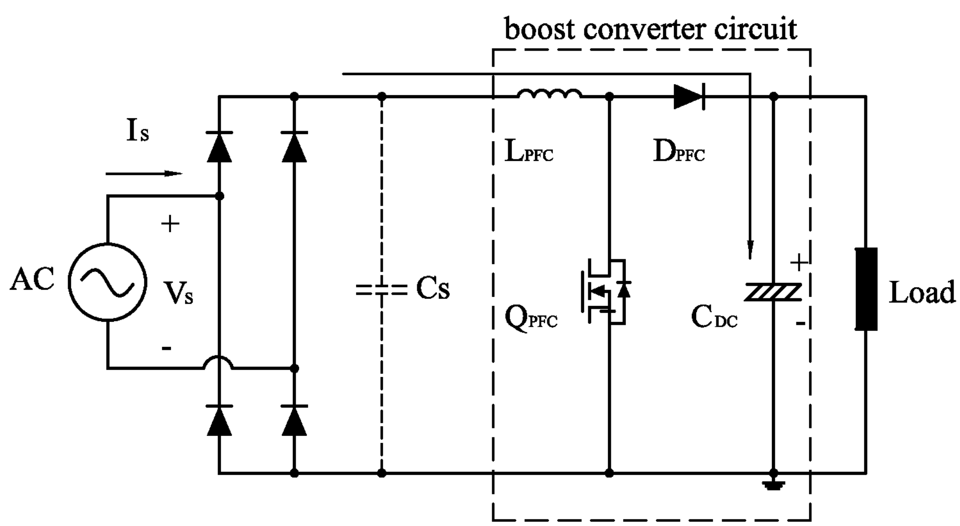

boost converter circuit
Is
AC
+
Vs
-
Cs
LPFC
DPFC
QPFC
CDC
+
-
Load

FIG. 1A

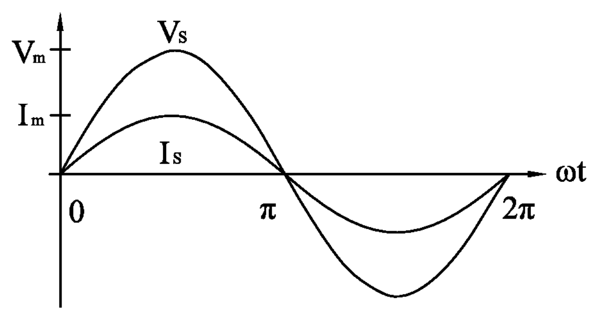

Vm
Vs
Im
Is
ωt
0
π
2π

FIG. 1B

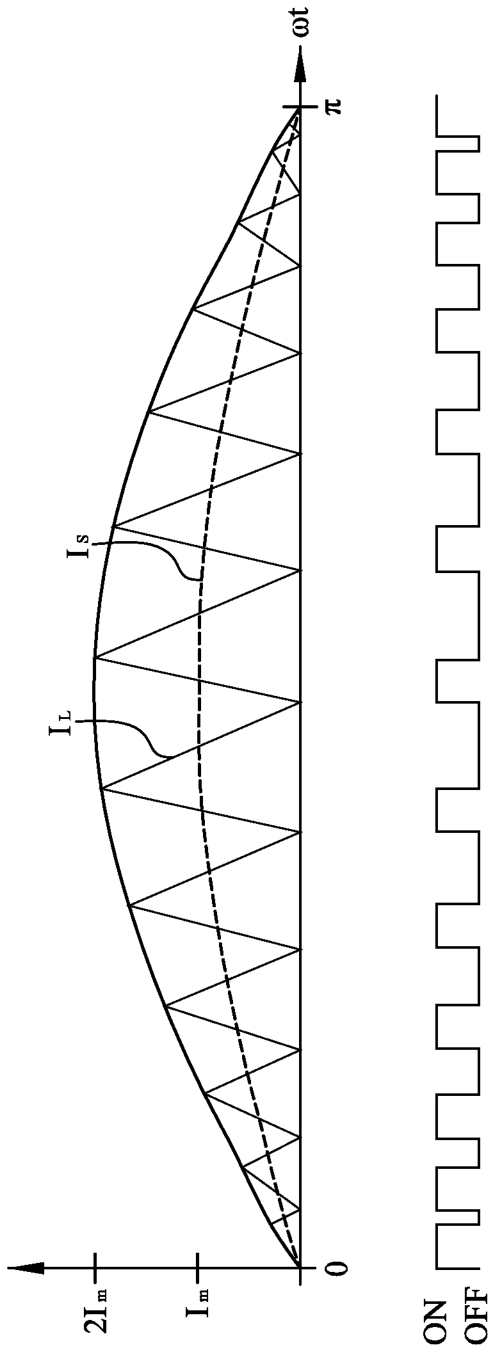


FIG. 1C

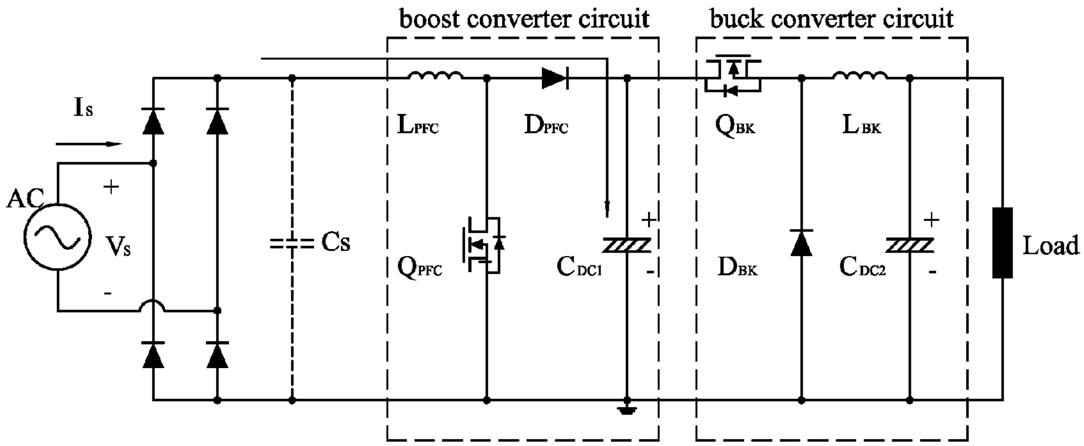

boost converter circuit
buck converter circuit
Is
AC
+
Vs
-
Cs
LPFC
DPFC
QPFC
CDC1
+
-
QBK
LBK
DBK
CDC2
+
-
Load

FIG. 2

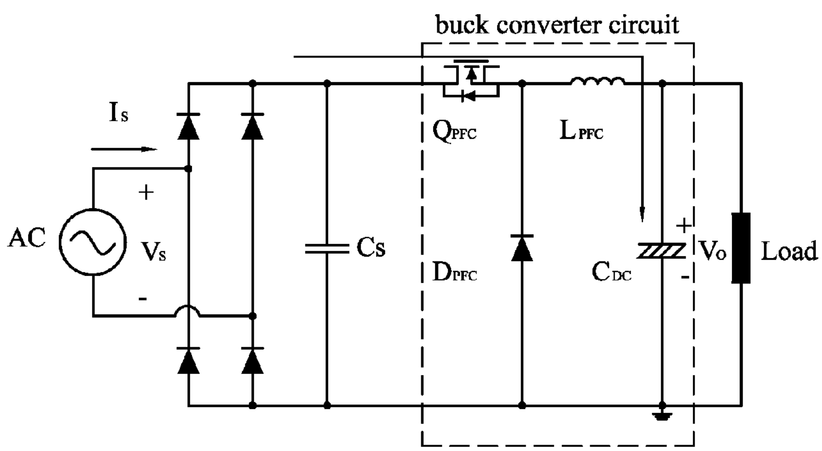

buck converter circuit
Is
AC
+
Vs
-
Cs
QPFC
LPFC
DPFC
CDC
+
-
Vo
Load

FIG. 3A

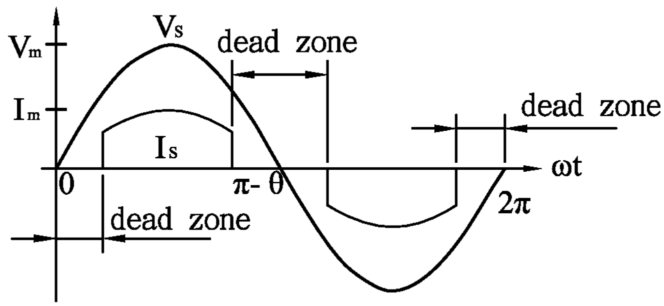

Vm
Im
Vs
dead zone
Is
0
π- θ
dead zone
dead zone
ωt
2π

FIG. 3B

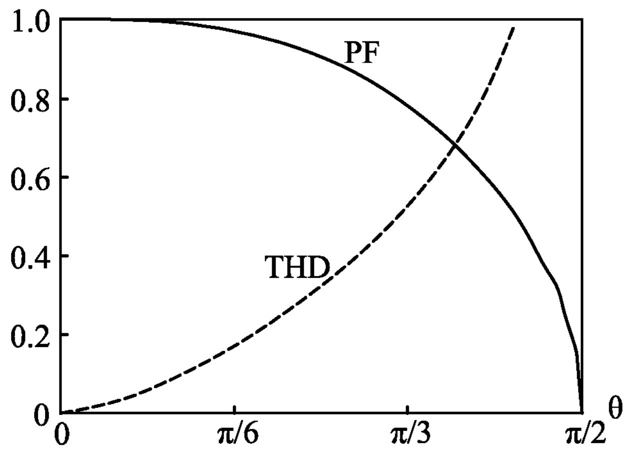

1.0
0.8
0.6
0.4
0.2
0
PF
THD
0
π/6
π/3
π/2
θ

FIG. 3C

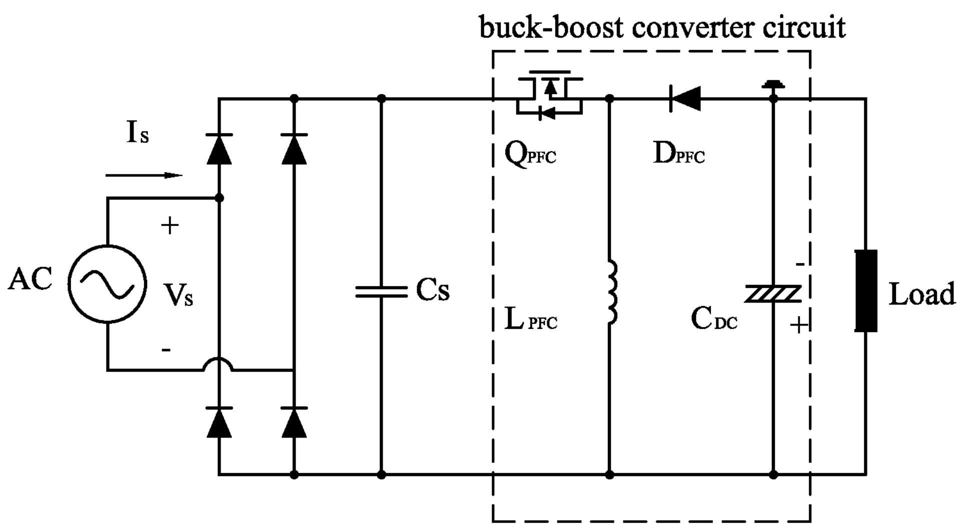
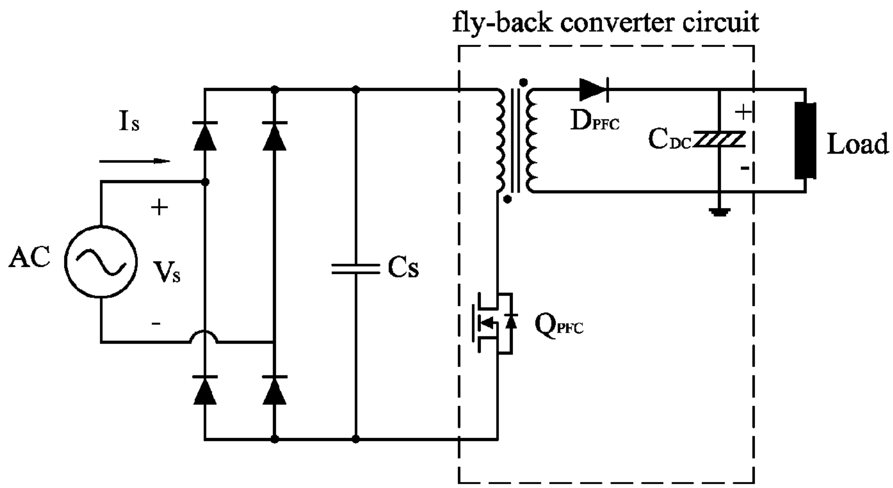
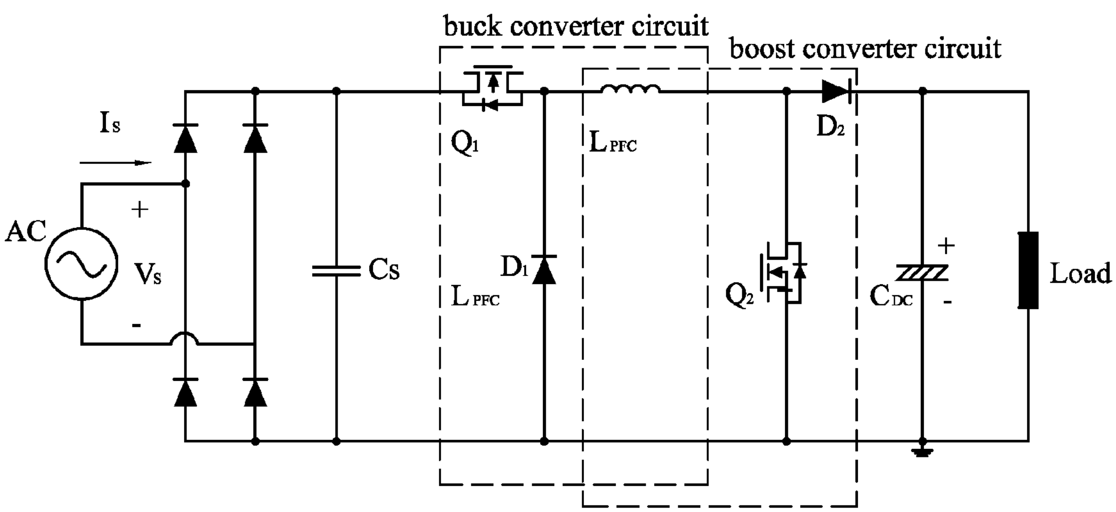

buck-boost converter circuit
Is
AC
+
Vs
-
Cs
QPFC
DPFC
L PFC
CDC
-
+
Load

FIG. 4



fly-back converter circuit
Is
AC
+
Vs
-
Cs
DPFC
CDC
+
-
Load
QPFC

FIG. 5



buck converter circuit
boost converter circuit
Is
AC
+
Vs
-
Cs
Q1
LPFC
D1
LPFC
D2
Q2
+
CDC
-
Load

FIG. 6

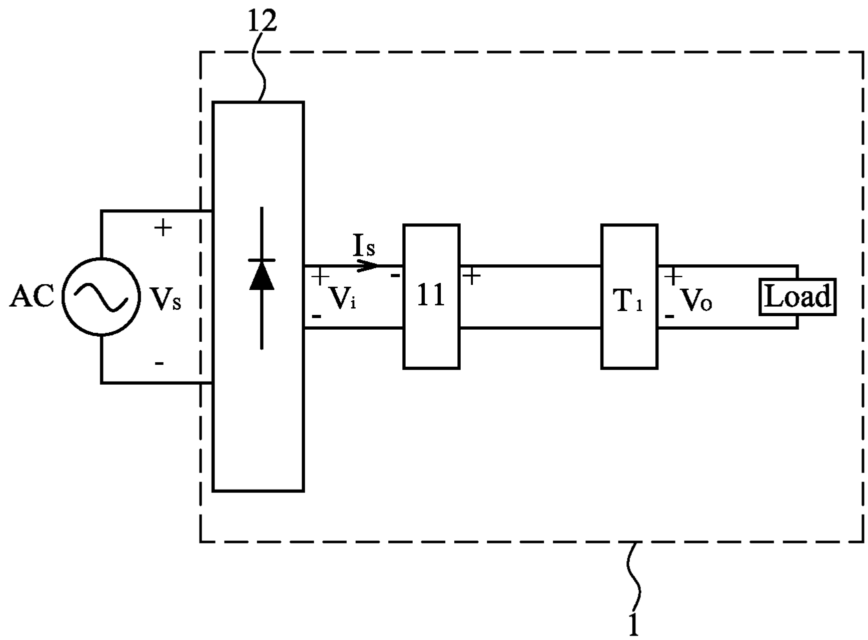

12
AC
Vs
+
-
Is
Vi
11
T1
Vo
Load
1

FIG. 7

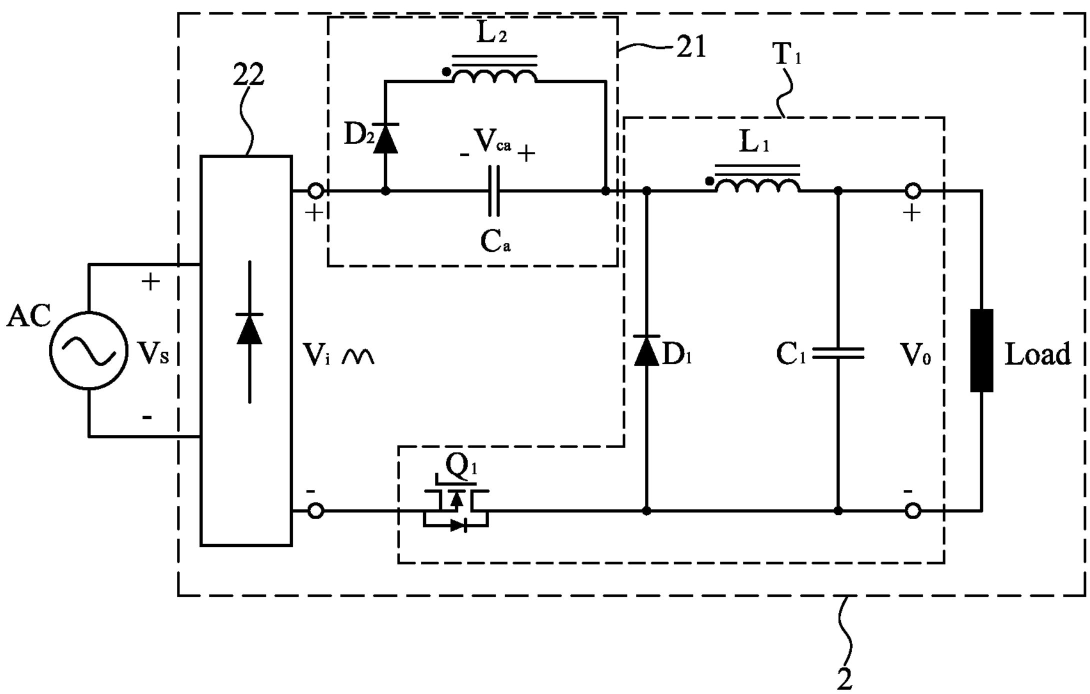
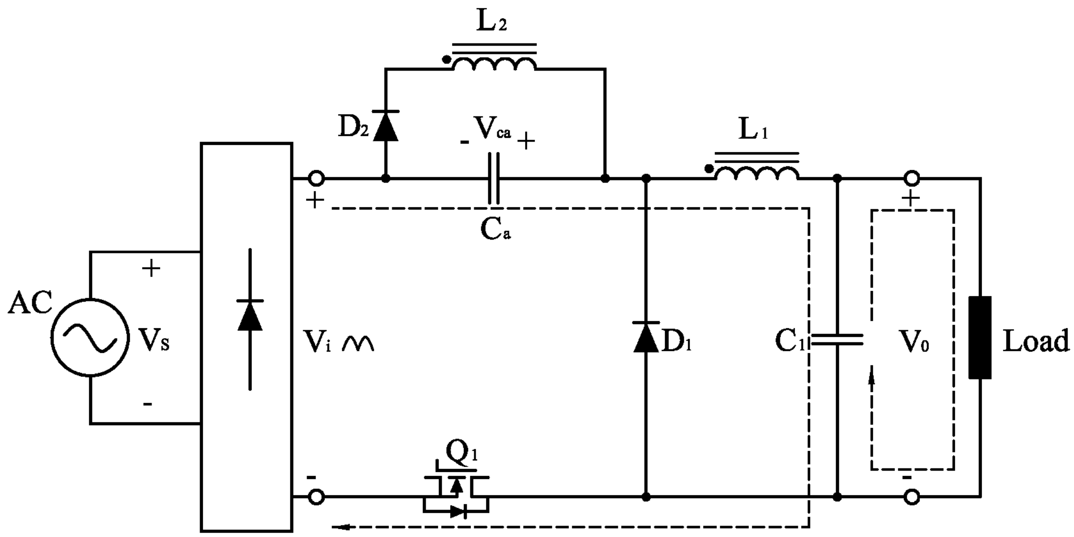
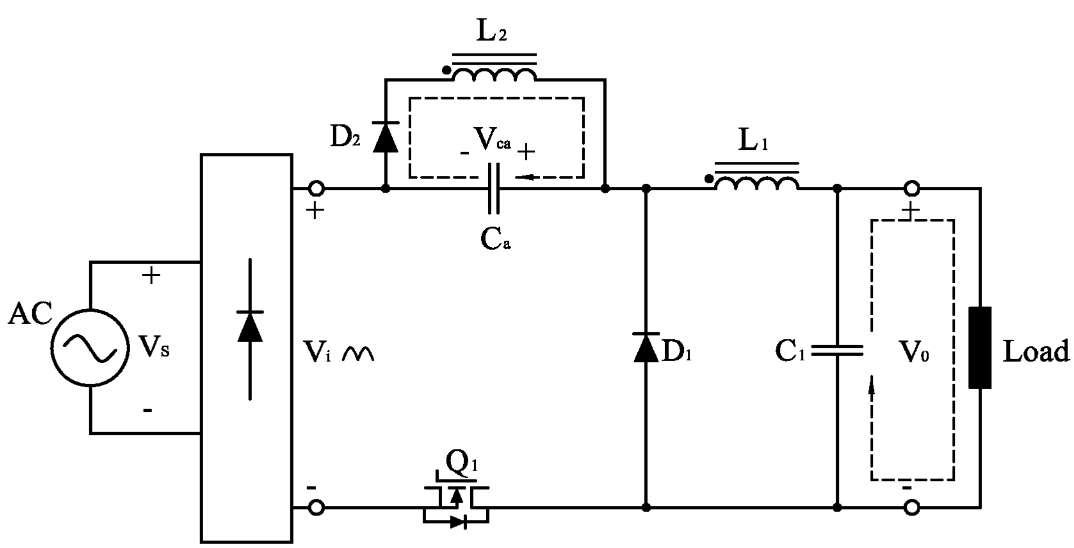

L2
21
T1
22
D2
Vca
L1
Ca
AC
Vs
Vi
D1
C1
V0
Load
Q1
2

FIG. 8



L2
D2
-Vca+
L1
+
Ca
AC
+
Vs
-
Vi
D1
C1
V0
Load
Q1
-
-

FIG. 9(A)



L2
D2
-Vca+
L1
+
Ca
AC
+
Vs
-
Vi
D1
C1
V0
Load
Q1
-
-

FIG. 9(B)

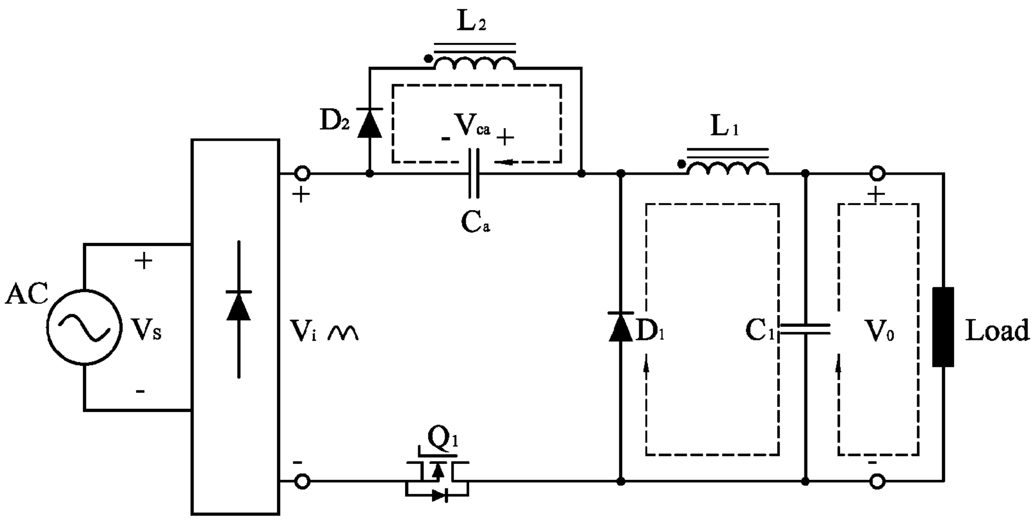

L2
D2
Vca
-
+
L1
+
Ca
+
AC
Vs
-
Vi
D1
C1
V0
Load
Q1
-
-

FIG. 9(C)

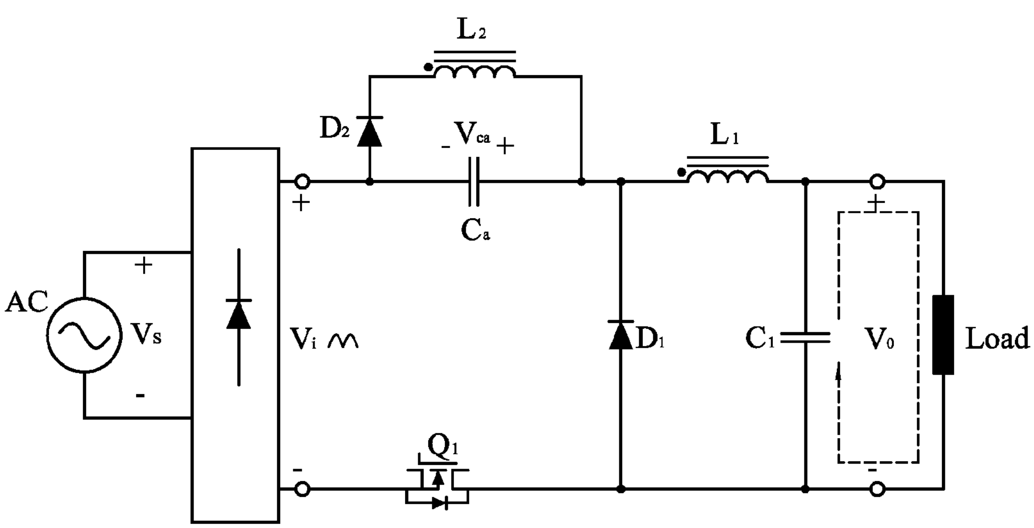

L2
D2
Vca
-
+
L1
+
Ca
+
AC
Vs
-
Vi
D1
C1
V0
Load
Q1
-
-

FIG. 9(D)

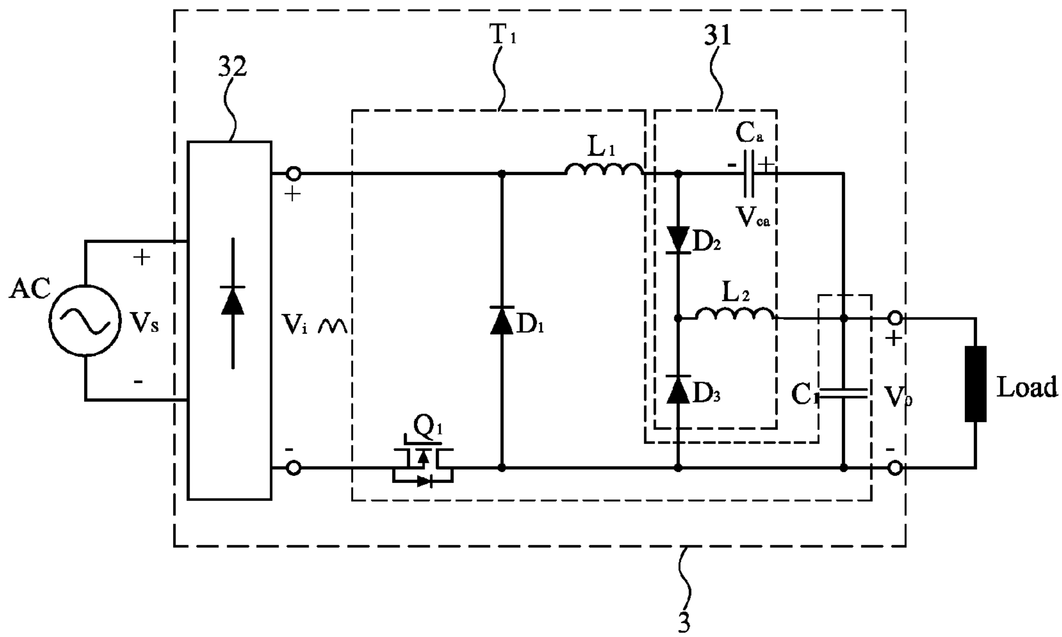


FIG. 10

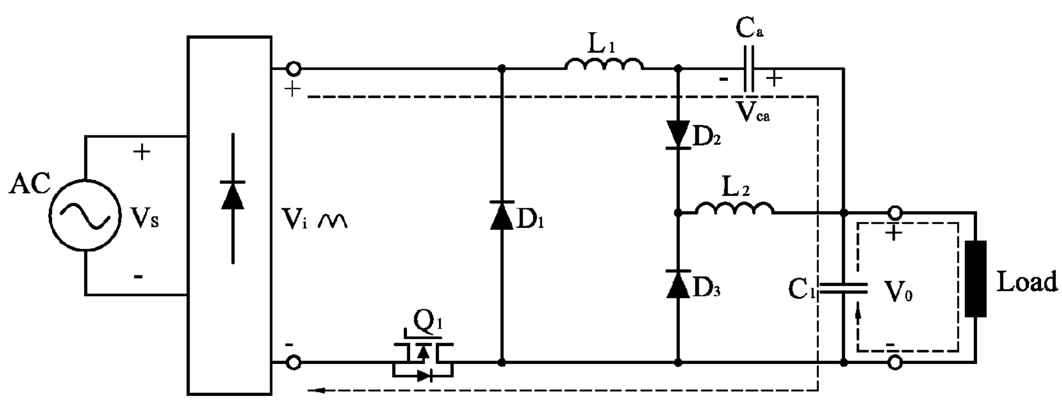


FIG. 11(A)

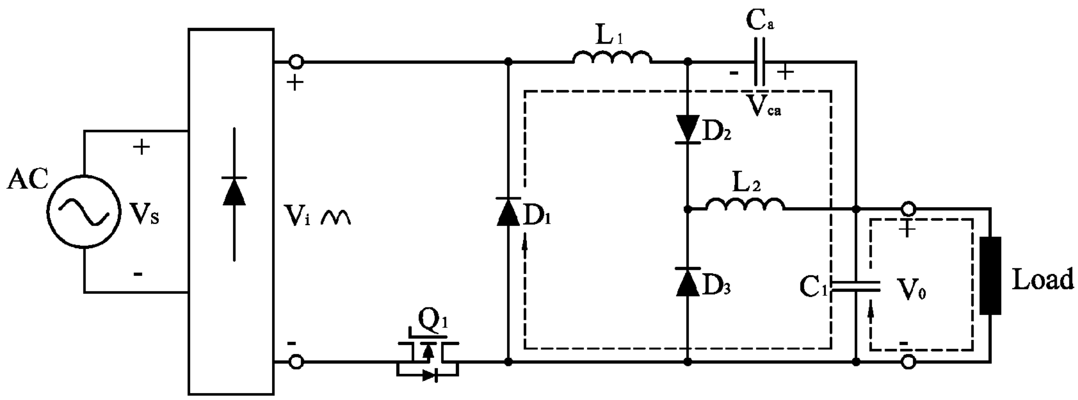


FIG. 11(B)

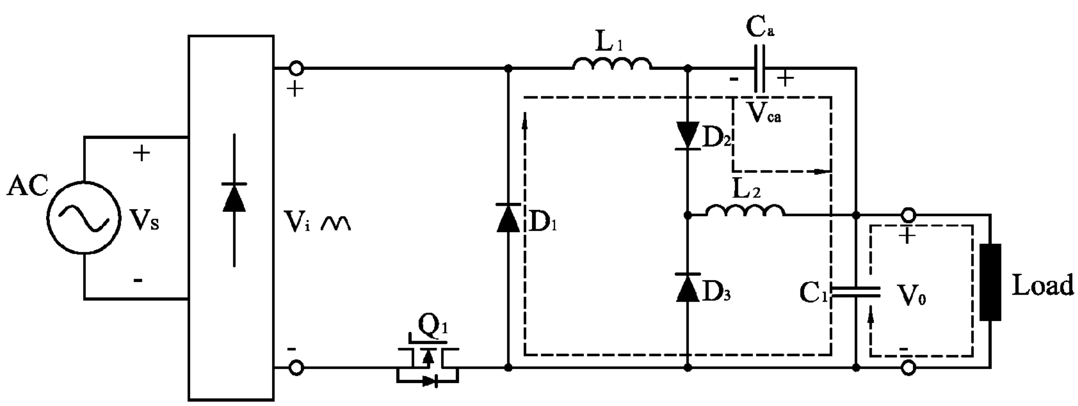


FIG. 11(C)

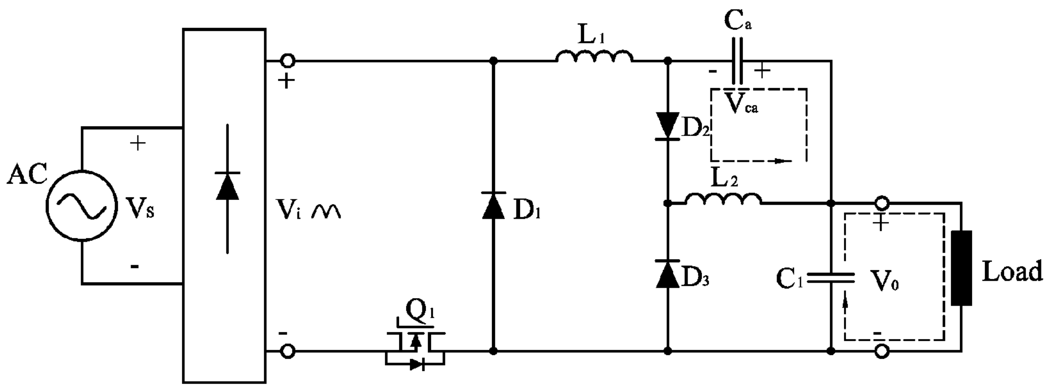


FIG. 11(D)

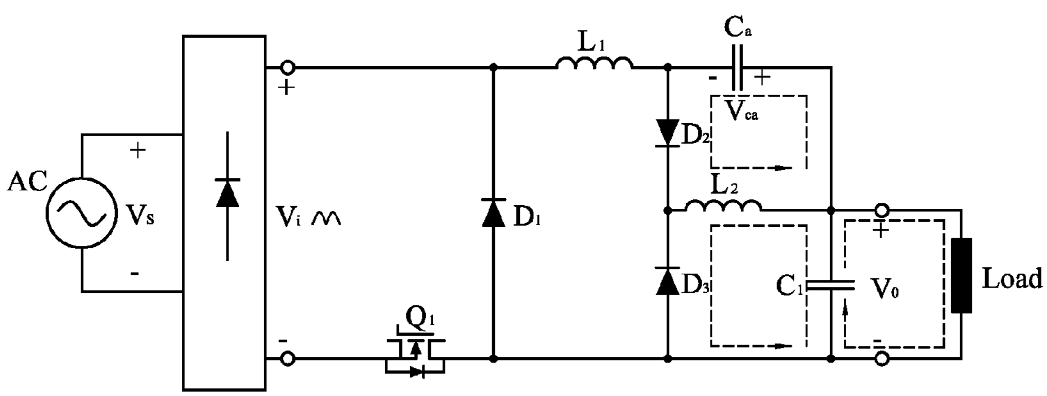


FIG. 11(E)

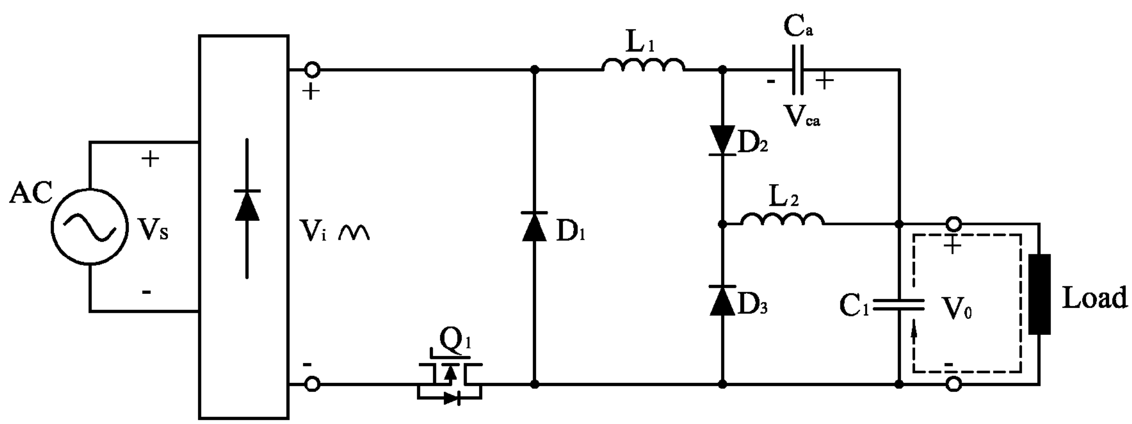


FIG. 11(F)

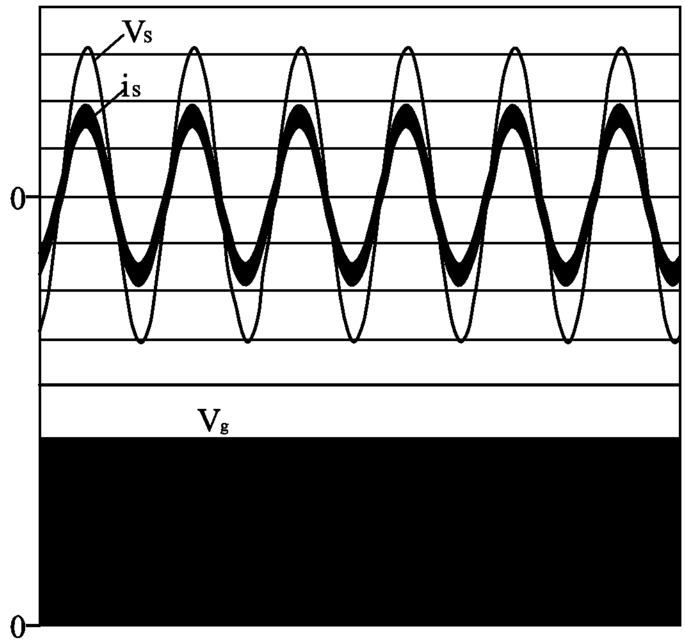


FIG. 12

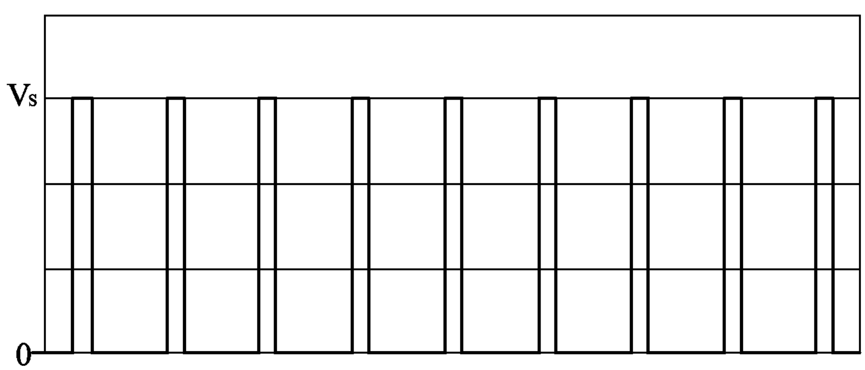


FIG. 13

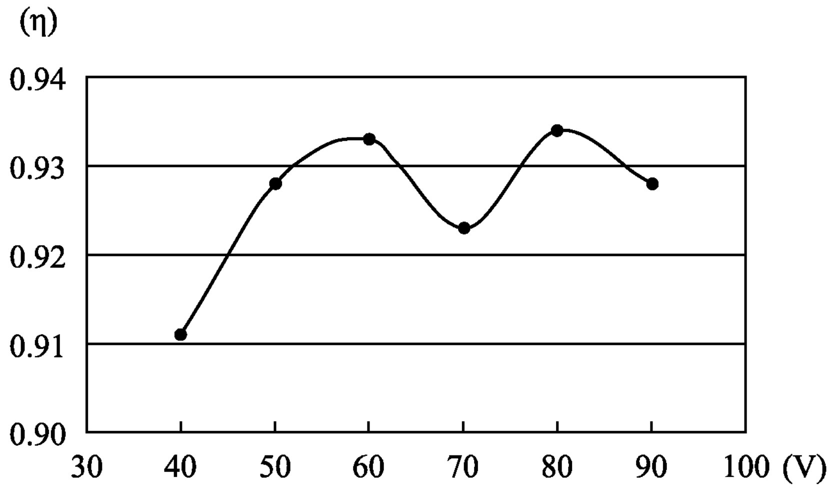


FIG. 14(A)

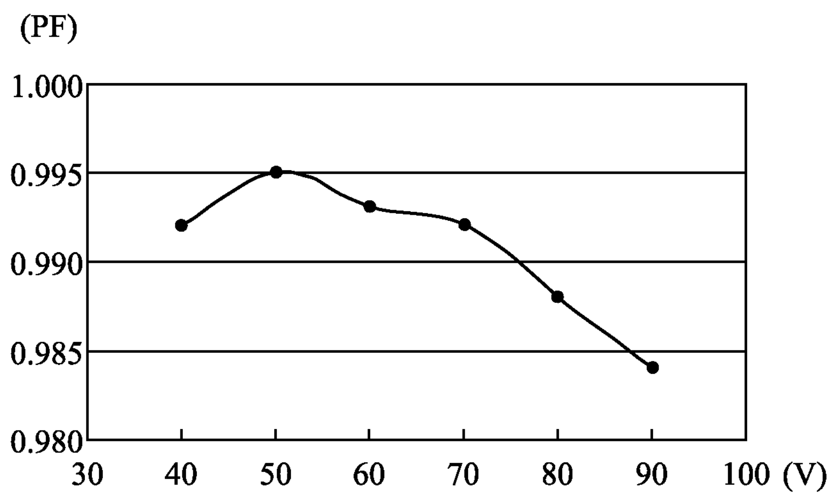


FIG. 14(B)

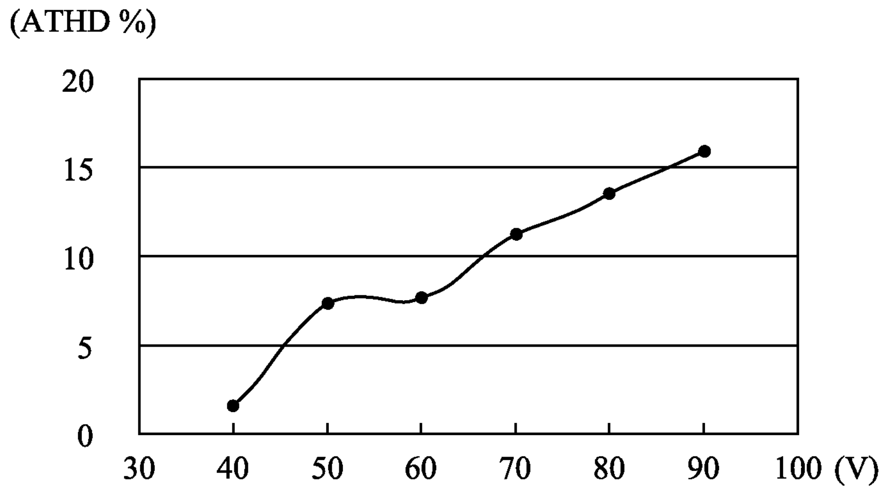


FIG. 14(C)

ACTIVE BUCK POWER FACTOR CORRECTION DEVICE

TECHNICAL FIELD

The present disclosure relates to an active buck power factor correction device, and more particularly, to an active buck power factor correction device that can be used in any kind of correction device with the output voltage lower than the peak voltage from AC source.

TECHNICAL BACKGROUND

A great number of current electrical appliances operate on direct current, and thus need alternating-direct current conversion since public electricity is alternating current. To reduce reactive power of an electronic system as well as to minimize current harmonics that cause system interference, a power factor corrector is prevailingly implemented in many electrical appliances that are required to have a high power factor and low current harmonics. A common power factor correcting circuit stereotypically adopts a boost approach, which is however set back by a limitation that a direct-current output voltage is necessarily higher than a peak value of an alternating-current input voltage. Further, although other circuits capable of outputting a lower voltage by means of buck or boost are available, these circuits suffer from drawbacks from having less satisfactory characteristics and efficiency, a large volume for a corresponding storage component, complex control means to low feasibilities.

FIG. **1**A shows a boost converter circuit frequently adopted by a conventional power factor corrector, which is advantaged by having a higher power factor and simpler control means. FIG. **1**B shows a schematic diagram of waveforms of an input voltage V_s and a current I_s of the conventional power factor corrector in FIG. **1**A, where ω is an angular frequency of public electricity, and V_m and I_m respectively represent a voltage peak and a current peak. In an optimal situation, the power factor of the input current I_s may approach 1.0. However, in the actual circuit application, the actual value of the power factor of the input current may approach above 0.98. In respect to the control of the switch element Q_{PFC}, the current in the store energy inductor L_{PFC} is the input current I_s and the charged voltage cross the strong energy inductor L_{PFC} is equal to the AC source under the boundary current mode (BCM) (as shown in the equation (1)). After filtering the component of the high frequency of the input current I_s the input current I_s is directly proportional to the input voltage V_s (as shown in the equation (2)), so as to accomplish the high power factor and perform the control of the boost power factor corrector.

$$i_{s(peak)} = i_{L_{PFC}(peak)} = \frac{\sqrt{2}\, v_s \sin\theta}{L_{PFC}} DT_s \tag{1}$$

$$i_{s(avg)} = i_{L_{PFC}(avg)} = \frac{\sqrt{2}\, v_s \sin\theta}{2L_{PFC}} DT_s \tag{2}$$

The two common methods to raise the power factor of the boost converter circuit: 1. zero-current cut and the constant on-time; 2. zero-current cut and double packets current cut-off. The two common methods both can implement the needed frequency and duty-cycle of the equation (2). Meanwhile, there are many ready-made IC accomplishing the two

common methods. FIG. **1**C illustrates relationship diagram among the input current I_s and the inductor current I_L of the boost converter circuit.

However, the limitation of the boost power factor corrector (or boost converter circuit) is that the input voltage must higher than the input voltage (peak voltage), and accompanied with a high output voltage, power components of the above conventional power factor corrector are often encountered with a higher voltage stress. In addition, for a load with a lower voltage requirement (lower than a peak voltage of the power source), the conventional boost power factor corrector, instead of directly providing an appropriate power source, is only able to provide a rated voltage needed by the load after stepping down its output voltage via a buck converting circuit, as shown in FIG. **2**. Yet, the above design increases a circuit size and production costs as well as circuit power consumption, such that conversion efficiency of an overall circuit is reduced as a result.

To optimize conversion efficiency of a circuit, a power factor corrector with a design of a buck converter circuit has also been proposed, as shown in FIG. **3**A. The major disadvantage of the buck power factor correction device is: the circuit can not receive the input current when the input voltage V_i from the AC source is lower than the output voltage V_o, and this phenomena is called “dead zone”, as shown in FIG. **3**B. Thereby, the input current I_s of the buck power factor correction device is discontinuous current, resulting in it has lower power factor and higher current resonance. Moreover, the bigger dead zone to cause the higher distortion rate and the current resonance, as shown in FIG. **3**C.

Another disadvantage of the buck power factor correction device is that of complicated control manner of the switch element being difficult to achieve. This is because the inductor current of the buck power factor correction device only flows through the AC source at the charged section, as shown in the equation (3). After filtering the component of the high frequency of the input current I_s the input current I_s is not directly proportional to the input voltage V_s (as shown in the equation (4)). At present, there is no the ready-made ICs or the control circuits accomplishing and overcoming the advantages of the buck power factor correction device.

$$i_{s(peak)} = i_{L_{PFC}(peak)} = \frac{\left(\sqrt{2}\, v_s \sin\theta - V_o\right)}{L_{PFC}} DT_s \tag{3}$$

$$i_{s(avg)} = i_{L_{PFC}(avg)} = \frac{\left(\sqrt{2}\, v_s \sin\theta - V_o\right)}{2L_{PFC}} D^2 T_s \tag{4}$$

There is also a buck-boost converter circuit (as shown in FIG. **4**) or a fly-back converter circuit (as shown in FIG. **5**) for serving as a power factor corrector. The two types of converting circuits above although indeed achieve a large power factor, due to the fact that the current path in converting circuits does not allow energy from the power source to directly charge the direct-current link capacitor, they are both disadvantaged by having a larger storage requirement for the inductor, a larger volume and poorer efficiency caused by magnetic energy loss.

There is yet another power factor corrector formed by integrating a boost converter circuit and a buck converter circuit, as shown in FIG. **6**. An active switch transistor **Q1** performs buck conversion when an active switch transistor **Q2** is off; the active switch transistor **Q2** performs boost conversion when the active switch transistor **Q1** is on. However, unless being implemented in a customized integrated for a specific use, such design is extreme complex and is rather highly unfeasible and unpractical.

TECHNICAL SUMMARY

In an embodiment, the present disclosure provides a power active buck power factor correction device, comprising: a AC source; a rectifying device coupled to the AC source for receiving and rectifying the AC source so as to generate an input voltage; a first converting device coupled to the rectifying device for receiving, transmitting, converting and storing energy so as to generate an output voltage; a load coupled to the first converting device; and an assistance device coupled to the first converting device for generating an assistance voltage. Specifically, the polarity of the assistance voltage is same with the input voltage, but is contrary to an output voltage, so that the first converting device may continue to work and receive an input current under the input voltage is smaller than the output voltage while the discontinue time of the input current is getting shorter so as to obtain the perfected power factor correction effect.

Further scope of applicability of the present application will become more apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the disclosure, are given by way of illustration only, since various changes and modifications within the spirit and scope of the disclosure will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure will become more fully understood from the detailed description given herein below and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present disclosure and wherein:

FIG. **1**A is a boost converter circuit generally adopted in a conventional power factor corrector;

FIG. **1**B is a schematic diagram of waveforms of an input voltage Vs and a current Is of the conventional power factor corrector in FIG. **1**A;

FIG. **1**C illustrates relationship diagram among the boost converter circuit, the input current I_s and the inductive current I_L;

FIG. **2** is a conventional power factor corrector comprising a two-order boost and buck converter circuits;

FIG. **3**A is a conventional power factor corrector comprising a buck converter circuit;

FIG. **3**B is a schematic diagram of waveforms of an input voltage Vs and a current Is of the conventional power factor corrector in FIG. **3**A;

FIG. **3**C illustrates relationship diagram between the ideal power factor and the distortion ratio of the current resonance of the conventional power factor corrector in FIG. **3**A;

FIG. **4** is a conventional power factor corrector comprising a buck-boost converter circuit;

FIG. **5** is a conventional power factor corrector comprising a fly-back converter circuit;

FIG. **6** is a conventional power factor corrector integrating a boost and buck converter circuits;

FIG. **7** illustrates an active buck power factor correction device **1** according to one embodiment of the present disclosure.

FIG. **8** illustrates one embodiment applying the structure shown in FIG. **7**.

FIGS. **9**(A), **9**(B), **9**(C) and **9**(D) illustrate circuit operations of the buck power factor correction device in FIG. **8**.

FIG. **10** illustrates another embodiment applying the structure shown in FIG. **7**.

FIGS. **11**(A), **11**(B), **11**(C), **11**(D), **11**(E) and **11**(F) illustrate circuit operations of the buck power factor correction device in FIG. **10**.

FIG. **12** illustrates the pulse width modulation (PWM) waveform diagram applying the input voltage, the input current and the high frequency switch control signal of the present disclosure.

FIG. **13** illustrates expend view applying the high frequency switch control signal of the present disclosure.

FIG. **14**(A) illustrates the relationship curve diagram between the conversion efficiency (η) and the input voltage in the present disclosure.

FIG. **14**(B) illustrates the relationship curve diagram between the power factor (PF) and the input voltage in the present disclosure.

FIG. **14**(C) illustrates the relationship curve diagram between the ampere total harmonic distortion (ATHD) of the circuit and the input voltage in the present disclosure.

DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

For your esteemed members of reviewing committee to further understand and recognize the fulfilled functions and structural characteristics of the disclosure, several exemplary embodiments cooperating with detailed description are presented as the follows.

FIG. **7** illustrates an active buck power factor correction device **1** according to one embodiment of the present disclosure. The active buck power factor device **1** comprises: an assistance device **11** and a first converting device T_1. The assistance device **11** is used for generating an assistance voltage. The first converting device T_1 is coupled to the assistance device **11** for transferring, storing and converting energy. Specifically, polarity of the assistance voltage is contrary to an output voltage V_o. The active buck power factor device **1** further comprises a rectifying device **12**, which is coupled to the assistance device **11** for receiving and rectifying a source so as to generate an input voltage V_i, and a load, which is coupled to the first converting device T_1, and the polarity of the assistance voltage is same with an input voltage V_i so as to decrease the discontinuous time of the input current I_s. Additionally, the first converting device T_1 may be a buck power factor correction device.

In the embodiment, the assistance voltage is serially coupled to the path in which the input current flows, and the polarity of the assistance voltage is same with the input voltage V_i so as to decrease the discontinuous time of the input current I_s. The assistance device **11** utilizes an assistance capacitor to be an assistance voltage element, and the designed assistance coil is coupled to the storing energy inductor in the first converting device T_1 so as to release the energy in the storing energy inductor to the output capacitor and simultaneously, the assistance capacitor is charged via the assistance coil, resulting in the polarity of the voltage cross the assistance capacitor is same with the input voltage V_i. Further, the coil number of the assistance coil is same with the assistance inductor, and simultaneously, the voltage cross the assistance capacitor is equal to the output voltage V_o so as to remove the dead zone.

FIG. **8** illustrates one embodiment applying the structure shown in FIG. **7**. The active buck power factor correction device **2** is adaptable to any kind of the power supply having the input voltage higher than the output voltage or buck power factor corrector, and the active buck power factor correction device **2** comprises: an assistance device **21** and a first converting device T_1. The buck power factor correction device **2** further comprises a rectifying device **22** and a load. In the embodiment, the first assistance device **21** comprises an assistance coil L_2, an assistance diode D_2 and an assistance capacitor C_a. The first converting device T_1 comprises: a storing energy inductor L_1, an active power switch Q_1, a diode D_1 and an output capacitor C_1. Specifically, the assistance coil L_2 in the assistance device **21** is serially coupled to the assistance diode D_2 and is coupled to the assistance capacitor C_a in parallel. The assistance coil L_2 consists of one or more coils. One terminal of the diode D_1 is coupled to the storing energy inductor L_1 and another terminal thereof is coupled to the output capacitor C_1, and one terminal of the storing energy inductor L_1 is coupled to the diode D_1 and another terminal thereof is coupled to the output capacitor C_1, and one terminal of the output capacitor C_1 is coupled to the storing energy inductor L_1 and another terminal thereof is coupled to the diode D_1, and coupled to the load in parallel, and one terminal of the active power switch Q_1 is coupled to the rectifying device **22** and another terminal is coupled to the output capacitor C_1.

Regarding to the circuit operations of the active buck power factor correction device **2** are as depicted bellows:

(1) Mode 1: Q_1 ON, D_1 OFF, D_2 OFF. Under the mode 1, when the active power switch Q_1 is ON, the input voltage V_i is added to the voltage V_{ca} (the assistance voltage) cross on the assistance capacitor C_a, and simultaneously, the storing energy inductor L_1 and the output capacitor C_1 are charged. The current on the storing energy inductor L_1 is increased, and the voltage V_{ca} (the assistance voltage) on the assistance capacitor C_a is decreased. This section is continuously operated until the active power switch is turned to OFF, and the operation is shown in FIG. **9**(A).

(2) Mode 2: Q_1 OFF, D_1 OFF, D_2 ON. Under the mode 2, after the active power switch Q_1 is OFF, the energy in the storing energy inductor L_1 is released. Since the storing energy inductor L_1 is coupled to the assistance coil L_2 each other, a coupling inductor is formed and it has the common store energy. Thereby, the stored energy in the inductor may be respectively released from the L_1 and L_2. In the embodiment, the coil number of the storing energy inductor L_1 is same with the assistance coil L_2, so the voltage cross on the storing energy inductor L_1 is equal to the assistance coil L_2. Because the voltage V_{ca} in the assistance capacitor C_a is decreased under mode 1, the voltage V_{ca} is smaller than the output voltage V_o ($V_{ca}<V_o$), and meanwhile, the assistance diode D_2 is firstly turned ON. The energy in the assistance coil L_2 is released via the assistance diode D_2 for charging the energy to the assistance capacitor C_a, so the voltage V_{ca} is increased and the voltage of the storing energy inductor L_1 is latched to V_{ca}, resulting in the diode D_1 is reverse biased and is turned OFF. This section is continuously operated until $V_{ca}=V_o$, and the operation is shown in FIG. **9**(B).

Mode 3: Q_1 OFF, D_1 ON, D_2 ON. Under mode 3, when the voltage V_{ca} of the storing energy L_1 is equal with the output voltage V_o, the diode D_1 is forward biased and is turned ON, and the energy in the storing energy inductor L_1 is discharged to the output capacitor C_1 via the diode D_1, and The energy in the assistance coil L_2 is released via the assistance diode D_2 for charging the energy to the assistance capacitor C_a, until the energy is completely released from the storing energy inductor L_1 and the assistance coil L_2 and the current is dropped to zero. The circuit operation in this section is shown in FIG. **9**(C).

Mode 4: Q_1 OFF, D_1 OFF, D_2 OFF. Under mode 4, after the energy is completely released from the storing energy inductor L_1 and the assistance coil L_2, the current is dropped to zero, the diode D_1 and the assistance diode D_2 are turned to OFF until the active power switch Q_1 is turned to ON and the state of the circuit regains the Mode 1. The circuit operation in this section is shown in FIG. **9**(D). In the embodiment, the energy that the load needs is proved by the output capacitor C_1.

FIG. **10** illustrates another embodiment applying the structure shown in FIG. **7**. The active buck power factor correction device **3** is adapted to any kind of the power supply having the input voltage higher than the output voltage or buck power factor corrector, and the active buck power factor correction device **3** comprises: an assistance device **31** and a first converting device T_1. And the active buck power factor correction device **3** further comprises a rectifying device **32** and a load. In the embodiment, the assistance device **31** comprises an assistance coil L_2, a first assistance diode D_2, a second assistance diode D_3 and an assistance capacitor C_a. The first converting device T_1 comprises a storing energy inductor L_1, an active power switch Q_1, a diode D_1, and an output capacitor C_1. Specifically, the first assistance diode D_2 is reversely coupled to the second assistance diode D_3, and one terminal of the first assistance diode D_2 is coupled to the assistance capacitor C_a and another terminal thereof is coupled to the assistance coil L_2, and the assistance coil L_2 consists of one or more coils, and one terminal of the assistance coil L_2 is coupled to the first assistance diode D_2 and the second assistance diode D_3 and another terminal thereof is coupled to the assistance capacitor C_a and the output capacitor C_1. And one terminal of the diode D_1 is coupled to the storing energy inductor L_1, and another terminal thereof is coupled to the active power switch Q_1 and the output capacitor C_1, and one terminal of the storing energy inductor L_1 is coupled to the diode D_1 and another terminal thereof is coupled to the assistance capacitor C_a, and the active buck power switch Q_1 is transistor, and the one terminal of the active buck power switch Q_1 is coupled to the rectifying device **32** and another terminal thereof is coupled to the diode D_1 and the output capacitor C_1, and one terminal of the output capacitor C_1 is coupled to the assistance capacitor C_a and another terminal thereof is coupled to the diode D_1 and is coupled to the load in parallel.

Regarding to the circuit operations of the active buck power factor correction device **3** are as depicted bellows:

(1) Mode 1: Q_1 ON, D_1 OFF, D_2 OFF, D_3 OFF. Under mode 1, when the active power switch Q_1 is ON, the input voltage V_i is added to the voltage V_{ca} (the assistance voltage) cross on the assistance capacitor C_a, and simultaneously, the storing energy inductor L_1 and the output capacitor C_1 are charged. The current on the storing energy inductor L_1 is increased, and the voltage V_{ca} (the assistance voltage) on the assistance capacitor C_a is decreased. This section is continuously operated until the active power switch Q_1 is turned to OFF, and the operation is shown in FIG. **11**(A).

(2) Mode 2: Q_1 OFF, D_1 ON, D_2 OFF, D_3 OFF. Under mode 2, after the active power switch Q_1 is OFF, the energy in the storing energy inductor L_1 is released, and the current in the storing energy inductor L_1 and the voltage V_{ca} (the assistance voltage) cross on the assistance capacitor C_a are continuously decreased. This section is continuously operated until $V_{ca}=0$, and the operation is shown in FIG. **11**(B).

(3) Mode 3: Q_1 OFF, D_1 ON, D_2 ON, D_3 OFF. Under mode 3, when the voltage V_{ca} is dropped to zero, the first assistance diode D_2 is forward biased and the current of the storing energy inductor L_1 simultaneously flows through the assis-

tance capacitor C_a and the first assistance diode D_2 and discharges the energy to the output capacitor C_1 until the energy in the storing energy inductor L_1 is completely released and the current in the storing energy inductor L_1 is dropped to zero. In this section, the assistance capacitor C_a is reversely charged, and the voltage V_{ca} cross the assistance capacitor C_a is turned to negative, and the current of the assistance coil L_2 is increased. The circuit operation of this section is shown in FIG. **11**(C).

(4) Mode 4: Q_1 OFF, D_1 OFF, D_2 ON, D_3 OFF. Under mode 4, after the energy in the storing energy inductor L_1 is completely released, the diode D_1 is turned OFF. Because the voltage V_{ca} cross on the assistance capacitor C_a is negative, the first assistance diode D_2 maintains ON, and a resonance circuit is formed by the assistance capacitor C_a and the assistance coil L_2. In this section, the energy in the assistance capacitor C_a is transferred to the assistance coil L_2, so the current in the assistance coil L_2 is increased until the energy in the assistance capacitor C_a is completely released and the voltage $V_{ca}=0$. Afterward, the energy in the assistance coil L_2 is transferred to the assistance capacitor C_a, and meanwhile, the current of the assistance coil L_2 is decreased and the voltage V_{ca} cross on the assistance capacitor C_a is increased. In the section, when $V_{ca}=V_o$, the circuit operation enters the mode 5. This circuit operation of this section is shown in FIG. **11**(D).

(5) Mode 5: Q_1 OFF, D_1 OFF, D_2 ON, D_3 ON. Under mode 5, when $V_{ca}=V_o$, the second assistance diode D_3 is turned to ON, the current in the assistance coil L_2 flows through the output capacitor C_1 and the assistance capacitor C_a. Because the output capacitor C_1 is coupled to the assistance capacitor C_a in parallel, the voltages of both are same. This section is continuously operated until the energy in the assistance coil L_2 is completely released, and the operation is shown in FIG. **11**(E).

(6) Mode 6: Q_1 OFF, D_1 OFF, D_2 OFF, D_3 OFF. Under mode 6, when the energy in the assistance coil L_2 is completely released, the first assistance diode D_2 and the second assistance diode D_3 are turned to OFF until the active power switch Q_1 is turned to ON and the state of the circuit regains the Mode 1. The circuit operation in this section is shown in FIG. **11**(F). In the embodiment, the energy that the load needs is proved by the output capacitor C_1.

FIG. **12** illustrates the pulse width modulation (PWM) waveform diagram applying the input voltage, the input current and the high frequency switch control signal of the present disclosure. FIG. **13** illustrates expand view applying the high frequency switch control signal of the present disclosure. In accordance with the FIGS. **12** and **13**, it obviously appears the control signal of the active power switch Q_1 in the present disclosure has the fixed frequency and the duty-ratio so as to achieve the high power factor and the low harmonic distortion. Compared with the convention boost and buck power factor correctors, the control manner of the present disclosure is simple and is easy implemented.

On the other hand, when the frequency or the duty-ratio of the control signal is modulated, the output voltage is also modulated so as to maintain the perfected power factor correction. FIG. **14** illustrates changes of the conversion efficiency (η), the power factor (PF) and the ampere total harmonic distortion (ATHD) of the circuit disclosed by the present disclosure when it uses the input voltage 110V and the output power 20 W in different output voltage V_o. As shown in FIGS. **14**(A)~(C), it obviously appears the conversion efficiency is 91~94% (see FIG. **14**(A)), PF maintains above 0.98 (see FIG. **14**(B)) and ATHD is 2~16% (see FIG. **14**(C) when the input voltage is 40~90V in the present disclosure. Thereby, the present disclosure not only obtains the high power factor and the low harmonic distortion, but also obtains good conversion efficiency.

The active buck power factor correction device uses a capacitor to be an assistance capacitor for adding extra driving potential to the input current, so as to solve the dead zone of the convention active buck power factor correction device. In respect to the control, it only uses the simple control manner to obtain many advantages, such as the high power factor, the low harmonic distortion and the good convention efficiency, etc. Besides, although the present disclosure merely disclose the buck power factor corrector with AC to DC, the skilled person should understand the buck power factor corrector with DC to DC is also applied in the present disclosure.

With respect to the above description then, it is to be realized that the optimum dimensional relationships for the parts of the disclosure, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed readily apparent and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present disclosure.

What is claimed is:

1. An active buck power factor correction device, comprising:

an assistance device, for generating a assistance voltage; and

a first converting device, coupled to the assistance device, for transferring, storing and converting energy, wherein the first converting device is a buck power correction device, and comprises a storing energy inductor, an active power switch, a diode and an output capacitor;

wherein a polarity of the assistance voltage is same with an input voltage, but is contrary to an output voltage; when the active power switch is ON, and the input voltage is added to the assistance voltage, and simultaneously, the storing energy inductor and the output capacitor are charged.

2. The active buck power factor correction device of claim **1**, further comprising:

a rectifying device, coupled to the assistance device, for receiving and rectifying a source so as to generate an input voltage; and

a load, coupled to the first converting device.

3. The active buck power factor correction device of claim **2**, wherein the assistance device comprises an assistance coil, an assistance diode and an assistance capacitor.

4. The active buck power factor correction device of claim **3**, wherein the assistance coil is serially connected to the assistance diode, and is connected to the assistance capacitor in parallel, and the assistance coil is an inductor coil, and the assistance coil is coupled with the storing energy inductor each other.

5. The active buck power factor correction device of claim **3**, wherein one terminal of the diode is coupled to the storing energy inductor and another terminal thereof is coupled to the output capacitor, and one terminal of the storing energy inductor is coupled to the diode and another terminal thereof is coupled to the output capacitor, and one terminal of the output capacitor is coupled to the storing energy inductor and another terminal is coupled to the diode and coupled to the load in parallel, and one terminal of the active power switch is coupled to the rectifying device and another terminal thereof is coupled to the output capacitor.

6. The active buck power factor correction device of claim **3**, wherein the power switch is OFF, and the assistance capacitor is charged via the assistance coil so as to generate the assistance voltage having the same polarity with the input voltage.

7. The active buck power factor correction device of claim **3**, wherein when the active power switch is OFF, the output capacitor and the assistance capacitor are charged by the storing energy inductor and the assistance coil, resulting in the polarity of the assistance voltage is contrary to the output voltage.

8. The active buck power factor correction device of claim **3**, wherein when the coil number of the storing energy inductor is same with the assistance coil, the voltage of the assistance is equal to the output voltage.

9. The active buck power factor correction device of claim **2**, wherein the assistance device comprises an assistance coil, a first assistance diode, a second assistance diode and an assistance capacitor, and the first converting device comprises a storing energy inductor, an active power switch, a diode and a output capacitor.

10. The active buck power factor correction device of claim **9**, wherein the first assistance diode is reversely coupled to the second assistance diode, and one terminal of the first assistance diode is coupled to the assistance capacitor and another terminal thereof is coupled to the assistance coil, and the assistance coil is an inductor coil, and one terminal of the assistance coil is coupled to the first assistance diode and the second assistance diode and another terminal thereof is coupled to the assistance capacitor and the output capacitor.

11. The active buck power factor correction device of claim **9**, wherein one terminal of the diode is coupled to the storing energy inductor and another terminal thereof is coupled to the active power switch and the output capacitor, and one terminal of the storing energy inductor is coupled to the diode and another terminal thereof is coupled to the assistance capacitor, and the active power switch is a transistor, and one terminal of the active power switch is coupled to the rectifying device and another terminal thereof is coupled to the diode and the output capacitor, and one terminal of the output capacitor is coupled to the assistance capacitor and another terminal of capacitor is coupled to the diode and is coupled to the load in parallel.

12. The active buck power factor correction device of claim **10**, wherein when the active power switch is ON, the input voltage is added to the assistance voltage, and simultaneously, the storing energy inductor and the output capacitor are charged.

13. The active buck power factor correction device of claim **10**, wherein when the active power switch is OFF, the energy in the storing energy inductor is released onto the assistance coil, and the output capacitor and the assistance capacitor are charged via the assistance coil, resulting in the polarity of the assistance voltage is contrary to the output voltage.

14. The active buck power factor correction device of claim **10**, wherein when the coil number of the storing energy inductor is same with the assistance coil, the assistance voltage is equal to the output voltage.

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